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Acquisition Level Definitions and Observables For Human Targets, Urban Operations, and The Global War on Terrorism

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This report describes revisions to the currently used definitions of target acquisition levels associated with the search and target acquisition process. These revised definitions address the classical acquisition terms of 1) detection, 2) classification, 3) recognition, and 4) identification.

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Purpose

This report describes revisions to the currently used definitions of target acquisition levels associated with the search and target acquisition process. These revised definitions address the classical acquisition terms of ***1) detection, 2) classification, 3) recognition, and 4) identification.*** The new definitions provide characteristic observables associated with the acquisition of humans and non-traditional military targets such as commercial vehicles. The observables were defined with specific emphasis on improving the ability to model search and target acquisition in Urban Operations and the Global War on Terrorism.

These definitions are applicable to entity level war-game simulations (Objective One SAF, CASTFOREM, COMBAT XXI) that employ the ACQUIRE search and target acquisition modeling methodology and to the performance specifications and measurement procedures used in the research, development, test, and evaluation of electro-optic and infrared sensors.

Background

The RDECOM Communications-Electronics Research, Development and Engineering Center (CERDEC) Night Vision and Electronic Sensors Directorate (NVESD) has conducted extensive research to determine the nature of the observables and the required image quality[1] (pixels on target, signal to noise, minimum resolvable temperature or contrast, etc) necessary to acquire (detect, classify, recognize, identify) traditional targets of military interest. The observables and image quality metrics have been well defined for such targets as tracked and wheeled combat vehicles and rotary wing aircraft. These definitions[2] and image quality metrics are well documented and have been integrated in to a number of entity level war-game simulations (OOS, COMBAT XXI, JCATS, etc) that employ the ACQUIRE search and target acquisition modeling methodology. These definitions and metrics are also extensively used throughout DoD and the defense industry as the basis for performance specifications and measurement procedures used in the research, development, test, and evaluation (RDTE) of electro-optic and infrared sensors.

While this body of research remains relevant to both the war-gaming and RDTE communities, there has been only recent emphasis placed on defining the relevant observables associated with targets of interest in urban operations, asymmetrical and low-intensity conflicts, and the emerging global war on terrorism. Further, there have been only a few of the many experimental field data collections that are necessary to quantify the image quality metrics that are used to predict or measure the probability of acquiring these "non-traditional" targets or items of interest.

Summary of Current Research and Methodology

For the past three years, NVESD, in conjunction with the TRADOC Analysis Center (TRAC), the Urban Operations Functional Area Collaborative Team (UO FACT), Program Manager for Soldier Equipment (PM-SEQ), and the Army Materiel Systems Analysis Agency (AMSAA), has been conducting laboratory and field research to characterize activities and observables related to search and target acquisition in the urban environment. This research has produced an initial set of observables of interest (single hand-held objects, two hand-held objects, uniforms, head-gear, modified "paramilitary" vehicles, etc) and the experimental field data used to establish the image quality metrics associated with the acquisition of those objects.

However, prior to this publication, there has been no methodical or logical association of these activities and observables with the traditional military target acquisition hierarchy. That classical acquisition hierarchy has four discrete "levels" referred to as 1) detection, 2) classification, 3) recognition, and 4) identification or DCRI. These acquisition levels have been defined in an operational context that attempts to provide increasing situational awareness regarding the target or object of interest, and to relate that situational awareness to the contemporary rules of

engagement. These definitions also relate to the degree that the observable features allow the observer to discriminate that target from other targets or from background. (The currently accepted DCRI definitions, circa 1992 as implemented in CASTFOREM, can be found at Appendix A.)

These new definitions were derived using a methodology and assumptions similar to those used in the past. Relative discrimination task difficulties between the categories are maintained. That is, identification is more difficult that recognition, recognition more difficult that classification, and classification more difficult than detection. To the maximum extent possible, a simple hierarchy should be maintained. For example, a T72 is a Tank is a Tracked Vehicle. A graphical view of this hierarch is provided in Appendix B.

These new definitions address the observables associated with determining if a human is armed or otherwise postured or equipped, such that the human may be determined to be a potential threat. They address acquisition and discrimination of objects that the human may wear or carry. A new category, feature identification, has been added to address such worn or carried objects, and facial recognition. The definitions also address commercial and modified commercial vehicles that may be of interest in urban or GWOT operations.

It should be noted that human discrimination, especially the determination of combatant versus non-combatant, does not fit into the simple hierarchical structure. Human identification relies on a combination of observables and individual discriminations, which must be evaluated together, and in conjunction with appropriate situational awareness information to reach a combatant/non-combatant determination. All of this information must be weighed together, and in relationship to the contemporary rules of engagement, to reach a shoot/no-shoot decision.

Revised DCRI Definitions

Detection. The determination that an object or location in the field of view may be of military interest such that the military observer takes an action to look closer: alters search in progress, changes magnification, selects a different sensor, or cues a different sensor.

Classification. The object is distinguished or discriminated by class, like wheeled or tracked, human or other animal. Possibilities are:

- Tracked vehicle
- Wheeled vehicle
- Rotary-wing aircraft
- Fixed-wing aircraft
- Humans
- Other animal
- All other non-military inanimate objects

Recognition.

a) For vehicles and weapons platforms, the object can be distinguished by category within a class, such as tank or personnel carrier in the class of tracked vehicles. Examples include, but are not limited to:

- Tracked military vehicle - air defense or personnel carrier or artillery or tank or utility vehicle
- Tracked commercial vehicle – dozer or excavator
- Wheeled military vehicle - air defense or personnel carrier or artillery or tank or utility vehicle

- Wheeled commercial vehicle – heavy transport, light transport, utility vehicle (pick-up or SUV), sedan

b) For humans, the perception of individual elements, a combination, or a lack of, equipment, hand-held objects, and/or posture that can be distinguished to the extent that the human is determined to be of special military interest. Examples include:

- Wearing head-gear
- Carrying single-hand held object(s)
- Carrying linear two-hand held object
- Wearing "load-bearing equipment"

Identification.

a) For military vehicles and weapons systems, the object is distinguished by model, such as M1A2 or T80. Examples include:

- M1A1 or M1A2
- BMP1 or BMP2 or BMP3

b) For commercial vehicles, the object is distinguished by typically known model types. Examples include:

- Box truck or single- unit combination (tractor-trailer) or multi-unit combination
- 4-dr sport utility vehicle or 2 door sport utility vehicle or 2 door pick-up
- 4-dr sedan, 2-dr coupe, 2-dr convertible
- Dozer or front-end loader or tractor or "other" agricultural vehicle

c) For humans, the perception of individual elements or a combination of elements, such as clothing, equipment, hand-held objects, posture, and/or gender that can be distinguished to the extent that the human is determined to be armed or potentially combatant. Examples include:

- Armored head-gear or construction helmet or turban, etc
- Hand-gun or grenade or cell phone
- Rifle or rake or shovel, etc
- Load-bearing equipment or "back-pack" or "nap-sack
- Uniformed infantry or police, or guard or non-uniformed "civilian"

Feature identification. (Graphical hierarchy provided in Appendix C)

a) Commercial vehicles can be distinguished by make and model. Examples include:

- Dodge 4-dr sedan, Audi 2-dr sedan, Porsche 2-dr convertible

b) Individual elements of clothing, equipment, hand-held objects, and/or gender can be discriminated by name or country/region of origin

- RPG-7 or AT-4
- M16 or AK-47
- Cell phone or revolver
- Uniform worn by French or US or Chinese infantry
- Facial recognition/identification (A particular person can be discriminated out of a crowd of "n" persons)

In none of these cases, is the force allegiance of the weapon system or human confirmed.

Relationship of the DCRI Definitions and Target Acquisition Modeling

The NVESD ACQUIRE model predicts the quality of a sensor image and, therefore, the ability of an observer to acquire a target. A target is acquired by differentiating it from the possible alternatives. The probability of target acquisition is determined by the size, contrast, and number of characteristic details visible to the observer. With increasing image quality (object size, contrast, and observable details), the observer is able to discriminate more features that uniquely differentiate that target from other targets or from background. This means that the features that uniquely define a target are those that differentiate that target from other targets or from background. Therefore, the task difficulty and the acquisition hierarchy depend on how much alike the targets look or the amount of target-like clutter in the background.

The user(s) of this report should also carefully note the wording of the target detection definition. From experience, we recognize that the meaning of *target detection* varies with operational circumstance. Sometimes a target is detected because it is in a likely place; sometimes a target is detected because it looks like a target (target recognition). Some analysts associate a degree of certainty with target detection; to them, *detection* means the object is of military interest. This is not consistent with our definition or current war game modeling. A target detection is typically preceded by a number of false alarms. The critical factor is that the observer does something different to further interrogate an object or area of interest. There is no inference, nor assumption, that the object or area is of military interest.

Supporting Research and the Development of Image Quality Metrics for the New DCRI Definitions

In 2003, NVESD initiated a project under the auspices of the UO FACT and NVESD mission funding to begin characterization of urban operations activities as it relates to target acquisition (i.e., target search and target identification). Since target search and discrimination are complementary and dependent, the original research plan included work in three areas: urban threat assessment, urban target discrimination, and urban target search. The research in each of these areas is necessary to implement an overall ACQUIRE methodology for urban operations in general, and human target discrimination in particular.

The urban threat assessment provided an initial list of target activities and objects to be modeled, derived from user input and analysis of human activities that would indicate a present threat.

The urban discrimination research resulted in new calibration parameters for the ACQUIRE model addressing field of view (FOV) search time and probability of discrimination of small single-handheld items such as guns, knifes, cell phones, etc., and two-handed items such as rifles, rocket-propelled grenades, brooms, etc., in the visible, infrared, and image intensifier bands[3]. This task was supported by a series of imagery data collections using urban sites and potential enemy locations that provided a database for perception experiments to determine what to look for and where in the imagery.

The urban target search research is being conducted in cooperation with AMSAA[4], and will build on the work that established the relationship between FOV search time and probability of identification of handheld objects. In order to make full use of this information in war games and simulations, the model must be extended to address field of regard (FOR) search time, probability of detection of humans (who would be holding the handheld object), and associated mean detection times. In addition, false alarm data and search rates will be generated to allow more realistic modeling of the entire process.

The above research has been supplemented by several other customer sponsored activities that will enable more diverse and robust field data collections, additional field and perception studies

to validate the experimentally derived model data, and a more thorough study regarding the various observables associated with identifying human threats.

PM-SEQ has sponsored efforts to collect additional imagery data of human subjects wearing a variety of military and paramilitary uniforms (to include various head gear, carried equipment, weapons, etc) and clothing that is typical of several different world regions, as well as, commercial vehicles that have been modified for military or paramilitary purposes. This data will be used to generate the sensor and image quality metrics required to establish the probability of acquisition of these various 'configured" humans and objects[5]. The PM-SEQ has also resourced a series of field DCRI tests that will serve to validate the model data.

Finally, the TRADOC Analysis Center and NVESD's Ground Combat Systems Division have sponsored a more in-depth study of the various observables that may contribute to discriminating potential combatants from non-combatants. This research will not only examine clothing, equipment, and carried items, but also will consider posture, motion, sequences of activity, and group dynamics as observables that enable discrimination of potential combatants. This study will also evaluate the contribution of a priori situational awareness information in aiding the discrimination process.

Our objective is to complete most of this research and validate the upgrades to the NVTHERM and ACQUIRE family of models by the end of 2006. The result will be significantly better modeling capability to support urban operations, GWOT, and asymmetrical warfare.

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Appendix A

Current DCRI definitions as implemented in OneSAF Testbed and CASTFOREM and the NVESD family of ACQUIRE models. Origin of these definitions is circa 1992.

Detection. An object of possible military interest has been acquired, but unconfirmed by recognition. The force of the target is not determined. Possibilities are:

- Vehicles, personnel, structures

Classification. The object is distinguished by class; like wheeled or tracked. The force of the target is not determined. Possibilities are:

- Tracked
- Wheeled
- DI (dismounted infantry)
- RWA (rotary-wing aircraft)
- FWA (fixed-wing aircraft)

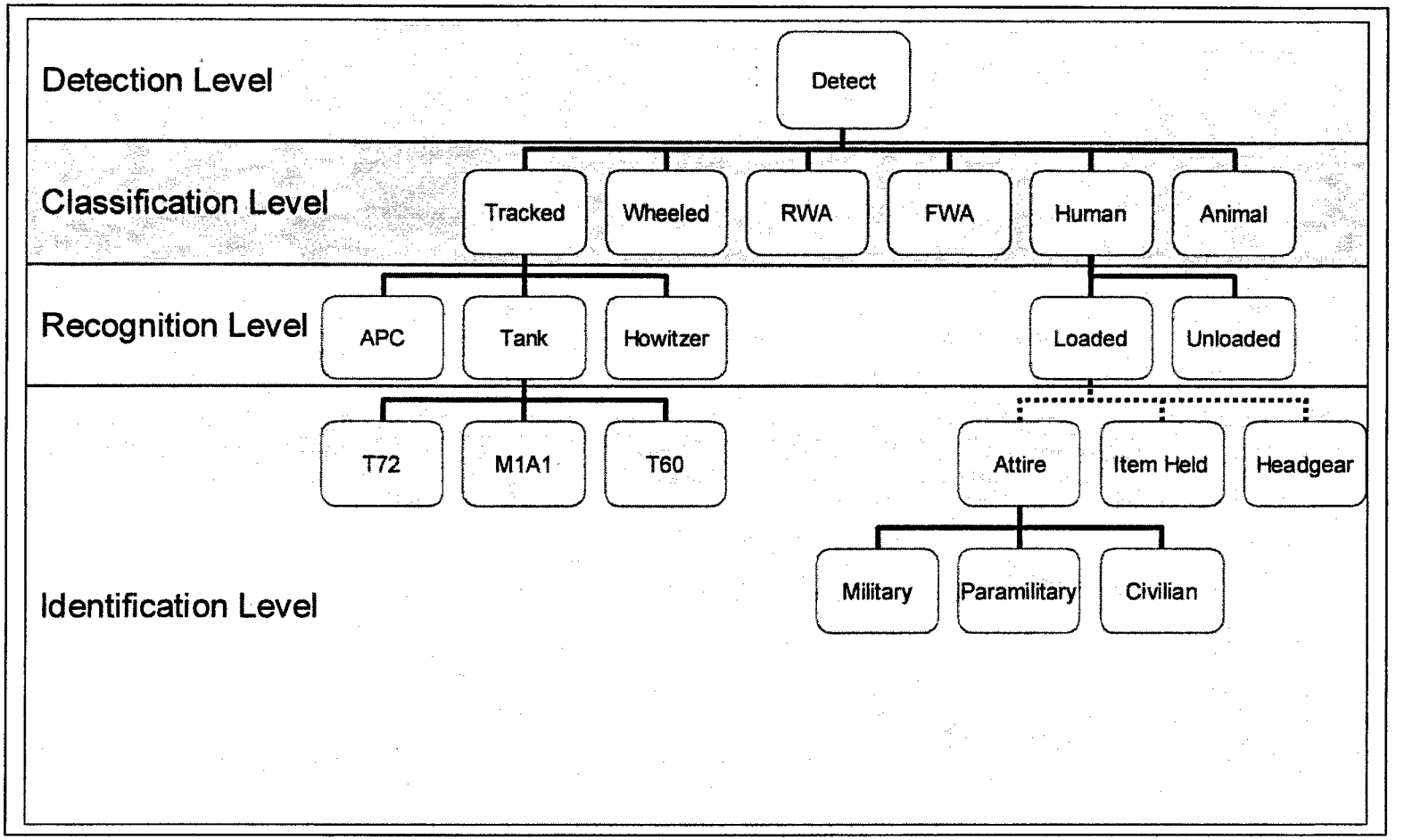
Recognition. The object is distinguished by category within a class, like tank vs. APC in the class of tracked vehicles. The force of the target is not determined (CID/IFF). Possibilities are (Not All Inclusive):

- Tracked air defense or personnel carrier or howitzer or truck or tank
- Wheeled air defense or personnel carrier or howitzer or truck or tank

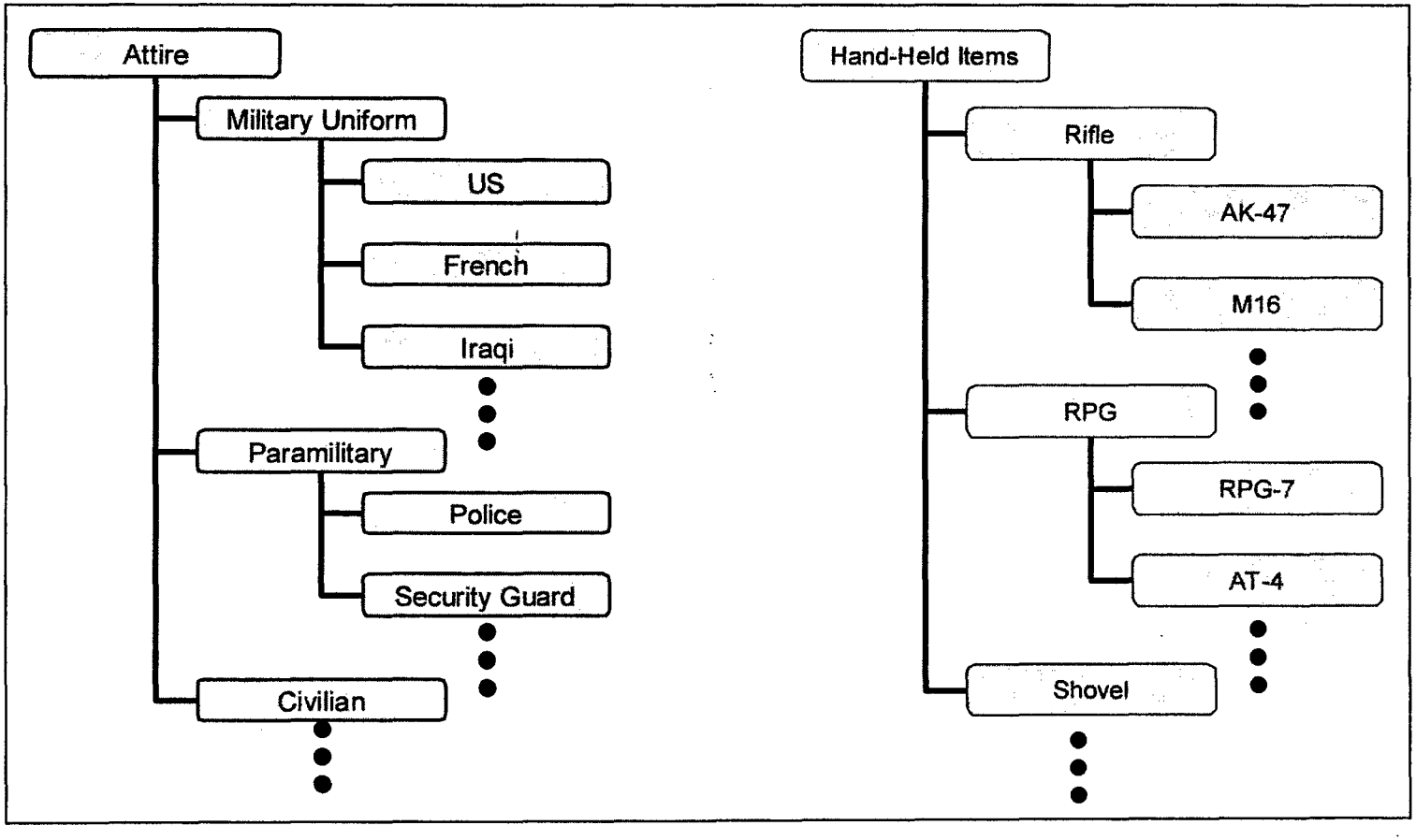
Identification. The object is distinguished by model, like M1A2 or T80. The force allegiance of the target is determined for CID. Examples include:

- M1A2 or M2A3
- T72 or T80 or T90
- BMP1 or BMP 2 or BMP 3

APPENDIX B: DCRI Hierarchy



APPENDIX C: Feature Identification Hierarchy



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